# Agricultural waste valorization – pyrolysis and torrefaction of leaves and stems obtained from tomato (*Solanum lycopersicum* L.)

J. Mokrzycki, P. Rutkowski

Faculty of Chemistry, Department of Polymer and Carbonaceous Materials, Wroclaw University of Science and Technology, Gdańska 7/9, 50-344 Wroclaw, Poland
jakub.mokrzycki@pwr.edu.pl

## 1. Introduction

Constantly increasing population of people force expansion of food industry. Annual production of tomato in Europe in 2015 was over 30.6 mln tones (statista.com). Cultivation of tomato both in soil and using hydroponics, generates huge amounts of waste leaves and stems, while tomato industry generates mostly waste peels and seeds. Many attention was paid to combustion of tomato wastes (Toscano, 2015). (González, 2004) studied combustion of pellets for domestic heating. Tomato pellets indicated good combustion properties in comparison to forest pellets. Other studies are focused on potential production of polyphenols (Kalogeropoulos, 2012), and valuable carotenoids like lycopene (Riggi, 2008), (Urbonaviciene, 2012).
The aim of this research was to investigate opportunity to improve waste biomass properties using torrefaction and pyrolysis processes.

## 2. Materials and methods

Waste tomato leaves and stems were collected after tomato cultivation and air dried. Biomass was then milled and sieved to a particle size of <0.4 mm. Pyrolysis and torrefaction were conducted in quartz reactor in $N_2$ flow of 20 L/h to ensure inert atmosphere of the process. Temperatures of the processes were 250, 300, 400, 500, 600 and 800°C with heating rate 10°C/min and residence time 1 hour. Proximate analyses were conducted to investigate content of: moisture (W), volatile matter (VM), ash (A) and fixed carbon (FC). To estimate the higher heating value (HHV) of obtained bio-chars Dulong's formula was used (Liu et al. 2014). SEM images were made using Jeol JSM-6610LVnx.

## 3. Results and discussion

Proximate analysis allowed to define volatile mater, moisture and ash content in derived samples. With increase of the process temperature the content of volatile matter decreased from 66% – raw material, to about 4% (dry basis). Ash content increased from 18.5% in raw material, up to 46% (dry basis) in bio-char obtained at 800°C respectively. Ultimate analysis indicated certain amounts of sulfur in obtained bio-chars. Sulfur content varied from 1% to 3% and increased with increase of the operating temperature. Presence of sulfur might be associated with presence of amino acids in raw material or with used

**Table 1.** Proximate analysis

| Temperature (°C) | Moisture, analytical (%) | Ash, dry (%) | Volatile matter, dry (%) | Fixed carbon, dry (%) |
|---|---|---|---|---|
| RT | 10.4 | 18.5 | 65.9 | 15.6 |
| 250 | 3.7 | 22.7 | 57.2 | 20.1 |
| 300 | 4.4 | 27.9 | 52.3 | 19.8 |
| 400 | 4.2 | 36.5 | 42.1 | 21.4 |
| 500 | 4.4 | 38.8 | 31.9 | 29.3 |
| 600 | 4.0 | 44.5 | 20.7 | 34.8 |
| 800 | 4.7 | 45.9 | 3.5 | 50.6 |

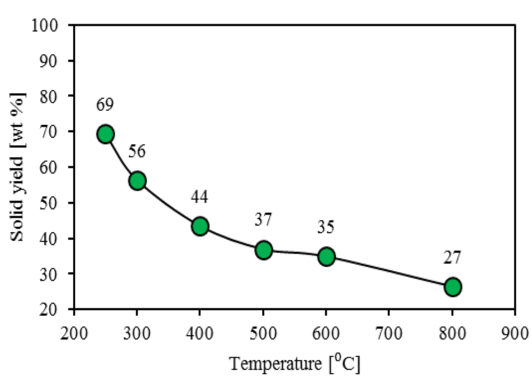


**Fig. 1.** Solid yield of obtained bio-chars.

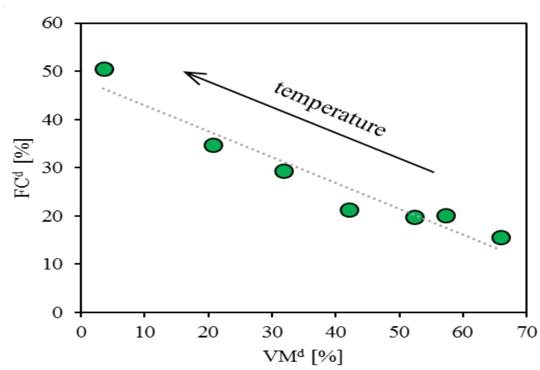


**Fig. 2.** Variation of fixed carbon and volatile matter of obtained bio-chars.

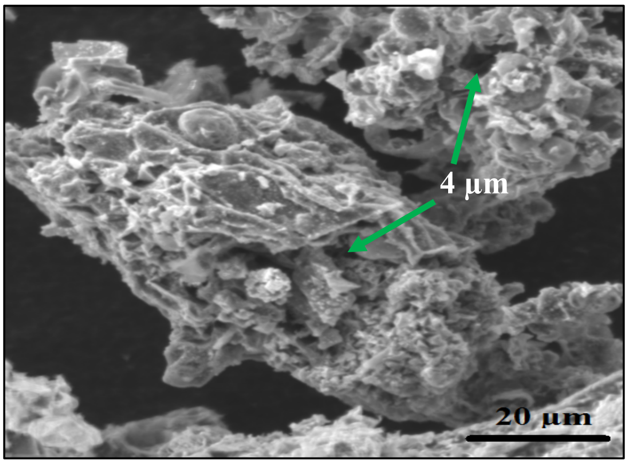


**Fig. 3.** SEM image of bio-char obtained at 800°C.

fertilizers. Fig. 1. presents the solid yield of obtained bio-chars. Solid yield varied from 27% to 69%. Table 1. contains results of proximate analyses of obtained bio-chars and variation of fixed carbon in function of volatile matter was shown in Fig. 2. Increase of the operating temperature resulted in decrease of volatile matter and as a result increase of fixed carbon content. In Fig. 3. SEM image of bio-char obtained at 800°C is presented. Small pores with diameter of about 4 µm can be observed. Porous-like texture of the material might be formed during release of the volatile matter. HHV of obtained bio-chars was calculated according to Dulong's formula. Raw material exhibited HHV 19 MJ/kg, while bio-char obtained at 500°C about 30 MJ/kg respectively. It might be caused by chemical composition of the material.

4. Conclusions

Conducted analyses allow to investigate properties of waste agricultural waste material. Tomato leaves and stems exhibit good potential as new materials for combustion processes. Ash content and presence of sulfur must be first limited to acceptable levels to reduce potential corrosive effects. Bio-char obtained at 500°C exhibits HHV comparable to coal (30 MJ/kg). Biomass might also find application as a potential activated carbon due to relatively high carbon content (about 70%). Agricultural application of bio-char as fertilizer might also be considered.

5. Acknowledgement

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6. References

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